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SEALING DEVICE

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FIELD OF THE INVENTION

The present invention relates to a sealing device, e.g., for a gas turbine or aircraft engine.

BACKGROUND INFORMATION

Gas turbines include a plurality of modules, for example a fan, a combustion chamber, e.g., a plurality of compressors, as well as a plurality of turbines. In the plurality of turbines, what is involved, e.g., is a high pressure turbine as well a low-pressure turbine, in the plurality of compressors, e.g., a high-pressure compressor as well as a low-pressure compressor. In a turbine, as well as in a compressor of a gas turbine, in the axial direction and the flow direction of the gas turbine, a plurality of vane rings are positioned one after another, each vane ring having a plurality of vanes positioned divided over the circumference. Between two respective adjacent vane rings a rotor blade ring is positioned in each case which has a plurality of rotor blades. The rotor blades are assigned to a rotor and rotate together with the rotor with respect to a fixed housing as well as the also fixedly developed vanes of the vane rings.

In order to optimize the efficiency of a gas turbine, leakages, on the one hand, between the rotating rotor blades and the fixed housing and, on the other hand, between the fixed vanes and the rotor have to be avoided by effective sealing systems. Thus, in order to seal such gaps, it is conventional that one may assign a honeycomb seal including a plurality of honeycomb seal cells to the stator, that is, the fixed housing or the radially inner ends of the fixed vanes, the honeycomb seal cells being separated from one another by walls. These honeycomb seals act together with sealing fins

assigned to the rotor or the rotating rotor blades, such a sealing fin rotating with respect to the honeycomb seal on the stator side.

According to the conventional arrangements, the walls that separate the honeycomb cells, of the honeycomb seal, from one another extend exactly in the radial direction, so that, for example, the sealing fins are aligned perpendicularly, relatively to the walls of the honeycomb seal cells that extend transversely to the direction of rotation of the sealing fins.

When the rotor, e.g., the sealing fins, brush(es) against the honeycomb seal on the stator side, the rotor accordingly impacts, in the axial view, the walls of the honeycomb seal cells that extend transversely to the direction of rotation of the rotor, whereby a force of resistance is set counter to the rotation or revolution of the rotor. For, walls of the honeycomb seal cells extending in such a manner are formed to be relatively stiff, and for this reason the walls of the honeycomb seal cells deform virtually not at all. When the rotor, and particularly the sealing fins, run into the honeycomb seal, therefore, according to conventional arrangements, the walls of the honeycomb seal cells are worn away from place to place. In this situation, accordingly, the honeycomb seal is damaged and the gap to be sealed is enlarged, which altogether is considered to be a disadvantage.

SUMMARY

Example embodiments of the present invention provide a sealing device, e.g., for a gas turbine or an aircraft engine.

According to example embodiments of the present invention, at least the walls of the honeycomb seal cells that extend transversely to the direction of rotation of the rotor are

placed radially at a slant in the direction of rotation of the rotor.

At least the walls of the honeycomb seal cells that extend transversely to the direction of rotation of the rotor are placed radially at a slant in the direction of rotation of the rotor. According to that, the walls of the sealing cells, in the axial direction of view, no longer extend perpendicular to the rotor, e.g., to the sealing fins, but rather these walls extend at a certain angle to the rotor. Thereby, a deformability of the walls of the honeycomb seal cells is made available, so that when the rotor, and, e.g., the sealing fins on the rotor side, brush against the honeycomb seal, a wearing away or a crack formation of the walls may be avoided. Using the present sealing device, accordingly an effective sealing of a gap between a rotor and a stator may be made possible.

The walls of the honeycomb seal cells that extend transversely to the direction of rotation of the rotor may be placed at a slant, in the direction of rotation of the rotor, such that edges of these walls facing the rotor are offset compared to edges of these walls facing away from the rotor, in the direction of rotation of the rotor. The edges of these walls facing the rotor and/or the edges of these walls facing away from the rotor are arched or extend in a straight line.

In addition to the walls of the honeycomb seal cells that extend transversely to the direction of rotation of the rotor, the walls of the honeycomb seal cells that extend in the direction of rotation of the rotor may also be placed at a slant.

Exemplary embodiments of the present invention are explained in more detail below with reference to the appended Figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic side view in the axial direction of view onto a honeycomb seal including a plurality of honeycomb seal cells of a sealing device according to a conventional arrangement.

Figure 2 is a schematic top view in the radial direction of view onto the honeycomb seal including a plurality of honeycomb seal cells as illustrated in Figure 1.

Figure 3 is a schematic side view in the axial direction of view onto a honeycomb seal including a plurality of honeycomb seal cells of a sealing device according to an exemplary embodiment of the present invention.

Figure 4 is a schematic top view in the radial direction of view onto the honeycomb seal including a plurality of honeycomb seal cells as illustrated in Figure 3.

Figure 5 is a schematic top view in the radial direction of view onto a honeycomb seal including a plurality of honeycomb seal cells of a sealing device according to an exemplary embodiment of the present invention.

Figure 6 is a schematic top view in the radial direction of view onto a honeycomb seal including a plurality of honeycomb seal cells of a sealing device according to an exemplary embodiment of the present invention.

DETAILED DESCRIPTION

Before exemplary embodiments of the present invention are explained with reference to Figures 3 to 6, a conventional sealing device is first described with reference to Figures 1 and 2.

Thus, Figures 1 and 2 illustrate in a largely schematic manner a honeycomb seal 10 of a conventional sealing device, between a rotor and a stator of a gas turbine. Figure 1 illustrates a schematic side view of honeycomb seal 10 in an axial direction of view, and Figure 2 illustrates a schematic top view of the same in a radial direction of view. The X coordinate of the coordinate system illustrated visualizes the radial direction, the Y coordinate visualizes the circumferential direction and the Z coordinate visualizes the axial direction. In the axial direction of view according to Figure 1, one is accordingly looking at the X-Y plane, and in the radial direction of view according to Figure 2 one is looking at the Y-Z plane.

Honeycomb seal 10 is formed from a plurality of honeycomb seal cells 11, honeycomb seal cells 11 illustrated in Figures 1 and 2 having a rectangular cross sectional area. It should be mentioned at this point that the honeycomb seals may also have a hexagonal cross sectional profile.

Honeycomb seal cells 11 of honeycomb seal 10 are bordered by a plurality of walls. Walls extend transversely to or along the direction of rotation of a rotor. The direction of rotation of a rotor is indicated in Figures 1 and 2 by an arrow 12. Walls of honeycomb seal cells 11 extending transversely to direction of rotation 12 are characterized by reference numeral 13, and walls of honeycomb seal cells 11 extending alongside or parallel to direction of rotation 12 are characterized by reference numeral 14.

As illustrated in Figure 1, according to a conventional arrangement, walls 13 of honeycomb seal cells 11 extending transversely to direction of rotation 12 of the rotor extend exactly in the radial direction, so that in the axial direction as illustrated in Figure 1 they are aligned perpendicular to direction of rotation 12 of the rotor. Thus,

according to a conventional arrangement, walls 13 that extend transversely to direction of rotation 12, form a resistance for rotor 12, since walls 13 thus arranged are relatively stiff, and are able to be only slightly deformed, if at all. When the rotor brushes against walls 13 that extend transversely to the direction of its rotation, material is accordingly removed from them, and they are damaged thereby.

Figures 3 and 4 illustrate a honeycomb seal 15 of a sealing device according to an example embodiment of the present invention, in different representations or directions of view, the directions of view of Figures 3 and 4 corresponding to the directions of view of Figures 1 and 2. Honeycomb seal 15 illustrated in Figures 3 and 4 also includes a plurality of honeycomb seal cells 16, honeycomb seal cells 16 having a rectangular contour in cross section. Honeycomb seal cells 16 are bordered by a plurality of walls which are aligned in optimized fashion relative to the direction of rotation (arrow 17) of a rotor.

In the exemplary embodiment illustrated in Figures 3 and 4, walls 18 of honeycomb seal cells 17 that extend transversely to the direction of rotation of the rotor are placed radially at a slant in the direction of rotation of the rotor. This inferrable from Figure 3 (corresponds to the axial direction of view), in which the radial slant position of walls 18 is illustrated. Walls 19 which extend alongside or parallel to direction of rotation 17 of the rotor, extend radially without such a slanted placement, as in the conventional arrangement.

Walls 18 of honeycomb seal cells 16 extending transversely to direction of rotation 17 of the rotor are, in this context, placed at a slant such that an edge 20 facing the rotor is offset from an edge 21 that faces away from the rotor in the direction of rotation of the rotor, which means that edge 20

facing the rotor, in direction of rotation 17, is positioned forward of, or downstream from edge 21 that faces away from the rotor. In the top view onto honeycomb seal 10 according to Figure 4 (corresponds to the radial direction of view) edges 20 and 21, that are thus offset, of walls 18 that extend transversely to direction of rotation 17 of the rotor, are illustrated as lines extending parallel to each other. Accordingly, edges 20, 21 of walls 18 extend in straight lines.

Figures 5 and 6 illustrate additional exemplary embodiments of honeycomb seals or sealing devices. Since the exemplary embodiments illustrated in Figures 5 and 6 substantially correspond to the exemplary embodiment illustrated in Figures 3 and 4, the same reference numerals are used for the same modules, to avoid unnecessary repetition.

The exemplary embodiment illustrated in Figure 5 differs from the exemplary embodiment illustrated in Figures 3 and 4 in that, in the case of honeycomb seal 22 of Figure 5, edges 20, facing the rotor, of walls 18 that extend transversely to direction of rotation 17 of the rotor, do not extend as straight lines, but rather are curved or arched. The curvature is in direction of rotation 17 of the rotor, in this example. Edges 21 facing away from the rotor, of walls 18 that extend transversely to the direction of rotation of the rotor, extend as straight lines. It should be pointed out that, in a difference from the arrangement illustrated in Figure 5, edges 21 facing away from the rotor may also be executed arched or curved, just as edges 20 of wall 18 that face the rotor.

Figure 6 illustrates an exemplary embodiment of a honeycomb seal 23, in which, in honeycomb seal 23 illustrated in Figure 6, in addition to walls 18 that extend transversely to

direction of rotation 17 of the rotor, walls 19 of honeycomb seal cells 16 that extend in the direction of rotation of the rotor are also placed at a slant. Thus, in the exemplary embodiment illustrated in Figure 6, also in the area of walls 19 that extend alongside or parallel to direction of rotation 17, the edges of the same kind are offset with respect to one another such that an edge 24, facing the rotor, of walls 19 is offset with respect to an edge 25 that faces away from the rotor, in the exemplary embodiment illustrated in Figure 6, edge 24, that faces the rotor, being curved, and edge 25 facing away from the rotor arranged as a straight line. By this measure, the flexibility of honeycomb seal cells 16 and walls 18, 19 of honeycomb seal cells 16 is able to be further optimized.

All the exemplary embodiments illustrated have in common that at least walls 18 of honeycomb seal cells 16 that extend transversely to the direction of rotation 17 of the rotor are placed radially at a slant in the direction of rotation of the rotor. For this, edges 20, 21, which border walls 18 that extend transversely to the direction of rotation of the rotor, are offset to one another. Edges 20, 21 extend either as straight lines or as curves.

This makes possible a good elastic as well as plastic deformability of the walls of the honeycomb seal cells, without the walls of the honeycomb seal cells being damaged or having material removed in response to the brushing of the rotor or the sealing fins on the rotor side against the honeycomb seal. The stress on the honeycomb seal may accordingly be reduced, whereby its service life may be increased. No undesired enlargement of the gap, that is to be sealed, may take place, and thus a greater sealing effect may be achieved. The sealing device may be used especially for sealing a radial gap between the radially inside ends of vanes

and a rotor. The honeycomb seals are then assigned to the radially inside ends of the vanes or of corresponding inner cover bands of the vanes, sealing fins assigned to the rotor acting together with the honeycomb seal. Using such a sealing device, it is also possible to seal a gap between the radially outer ends of the rotating rotor blades and a fixed housing. The use of the sealing device may be provided in the compressor region or turbine region of a gas turbine, e.g., in an aircraft engine.